PATENT ABSTRACTS OF JAPAN

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(71)Applicant : SONY CORP
(72)Inventor : KONDO TETSUJIRO
ANDO KAZUTAKA

(54) DATA PROCESSORDATA PROCESSING METHOD AND MEDIUM

(57)Abstract:
PROBLEM TO BE SOLVED: To improve the processing performance of data.
SOLUTION: For respective directions D1D2...D16 whose start point is a center pixelbased on the waveform characteristics (characteristics of pixel value) of an SD pixel present in the directionthe SD pixel for finally constituting a tap is decided. That isfor the respective directions Dibased on the waveform characteristics of an SD image present in the directionthe position of the SD pixel for constituting the tap present in the direction is moved.

CLAIMS

[Claim(s)]
[Claim 1]A data processing device which processes input data and predicts output data to the input datacomprising:
A determination means to determine two or more data extracted from said input data based on the waveform characteristic of said input data.
An extraction means to extract two or more data from said input data according to determination in said determination means about attention output data which is said output data which is going to calculate a predicted value.
A prediction means which calculates a predicted value of said attention output data based on two or more data extracted in said extraction means.

[Claim 2]Based on two or more data extracted in said extraction meansclass sorting is performed about said attention output dataThe data processing device

according to claim 1wherein said prediction means calculates a predicted value of said attention output data using a predetermined prediction coefficient corresponding to said class codeincluding further a class sorting means to output a corresponding class code.
[Claim 3]The data processing device according to claim 2wherein said prediction means linearity-primary-predicts said attention output data using said prediction coefficient.
[Claim 4]The data processing device according to claim 3wherein said prediction means linearity-primary-predicts said attention output data using said prediction coefficient and two or more data extracted in said extraction means.
[Claim 5]The data processing device according to claim 2 including further a prediction coefficient memory measure which has memorized said prediction coefficient for said every class code.
[Claim 6]The data processing device according to claim 1wherein said determination means detects an extremum of said input data and determines two or more data extracted from said input data based on the detection result.
[Claim 7]The data processing device according to claim 1wherein said determination means calculates a difference value of said input data and determines two or more data extracted from said input data based on the result of an operation.
[Claim 8]The data processing device according to claim 1wherein said determination means determines two or more data which calculates an error of said input data to a function which approximates said input dataand is extracted from said input data based on the result of an operation.
[Claim 9]The data processing device according to claim 1wherein said input data and output data are image data.
[Claim 10]The data processing device according to claim 9wherein said extraction means extracts a pixel which exists on the outskirts spatially or in time from image data as said input data to a pixel as said attention output data.
[Claim 11]A data processing method which processes input data and predicts output data to the input datacomprising:
A determination step which determines two or more data extracted from said input data based on the waveform characteristic of said input data.
An extraction step which extracts two or more data from said input data according to determination in said determination step about attention output data which is said output data which is going to calculate a predicted value.
A prediction step which calculates a predicted value of said attention output data based on two or more data extracted in said extraction step.

[Claim 12]A medium which makes a computer execute a program for performing data processing which processes input data and predicts output data to the input datacomprising:
A determination step which determines two or more data extracted from said input data based on the waveform characteristic of said input data.

An extraction step which extracts two or more data from said input data according to determination in said determination step about attention output data which is said output data which is going to calculate a predicted value.
A prediction step which calculates a predicted value of said attention output data based on two or more data extracted in said extraction step.

[Claim 13]A data processing device which learns a prediction coefficient used for predicting output data [as opposed to / process input data and / the input data] characterized by comprising the following.
A creating means which generates student data which serves as a student from teacher data which serves as a teacher for study of said prediction coefficient.
A determination means to determine two or more data extracted from said student data based on the waveform characteristic of said student data.
An extraction means to extract two or more data from said student data according to determination in said determination means about attention teacher data which is said teacher data which is going to calculate a predicted value.
A calculating means which calculates said prediction coefficient based on two or more data extracted in said extraction means.

[Claim 14]Based on two or more data extracted in said extraction meansclass sorting is performed about said attention teacher dataThe data processing device according to claim 13 characterized by said calculating means containing ** in quest of said prediction coefficient using two or more data extracted in said extraction means for said every class code including further a class sorting means to output a corresponding class code.
[Claim 15]The data processing device according to claim 13wherein said calculating means calculates said prediction coefficient for said teacher data to be obtained by linearity primary prediction.
[Claim 16]The data processing device according to claim 15wherein said calculating means calculates said prediction coefficient for said teacher data to be obtained by linearity primary prediction using two or more data extracted in said extraction means.
[Claim 17]The data processing device according to claim 13wherein said determination means detects an extremum of said student data and determines two or more data extracted from said student data based on the detection result.
[Claim 18]The data processing device according to claim 13wherein said determination means calculates a difference value of said student data and determines two or more data extracted from said student data based on the result of an operation.
[Claim 19]The data processing device according to claim 13wherein said determination means determines two or more data which calculates an error of said student data to a function which approximates said student dataand is extracted from said student data based on the result of an operation.
[Claim 20]The data processing device according to claim 13wherein said student

data and teacher data are image data.
[Claim 21]The data processing device according to claim 20wherein said extraction means extracts a pixel which exists on the outskirts spatially or in time from image data as said student data to a pixel as said attention teacher data.
[Claim 22]A data processing method which learns a prediction coefficient used for predicting output data [as opposed to / process input data and / the input data] characterized by comprising the following.
A generation step which generates student data which serves as a student from teacher data which serves as a teacher for study of said prediction coefficient.
A determination step which determines two or more data extracted from said student data based on the waveform characteristic of said student data.
An extraction step which extracts two or more data from said student data according to determination in said determination step about attention teacher data which is said teacher data which is going to calculate a predicted value.
An arithmetic step which calculates said prediction coefficient based on two or more data extracted in said extraction step.

[Claim 23]A medium which makes a computer execute a program for performing data processing which learns a prediction coefficient used for predicting output data [as opposed to / process input data and / the input data] characterized by comprising the following.
A generation step which generates student data which serves as a student from teacher data which serves as a teacher for study of said prediction coefficient.
A determination step which determines two or more data extracted from said student data based on the waveform characteristic of said student data.
An extraction step which extracts two or more data from said student data according to determination in said determination step about attention teacher data which is said teacher data which is going to calculate a predicted value.
An arithmetic step which calculates said prediction coefficient based on two or more data extracted in said extraction step.

[Claim 24]A data processing device which processes input data characterized by comprising the followingand is provided with the 1st device that predicts output data to the input dataand the 2nd device that learns a prediction coefficient used for predicting said output data.
The 1st determination means that determines two or more data which extracts said 1st device from said input data based on the waveform characteristic of said input data.
The 1st extraction means that extracts two or more 1st data from said input data according to determination in said 1st determination means about attention output data which is said output data which is going to calculate a predicted value.
A creating means which generates student data which serves as a student from teacher data in which said 2nd device serves as a teacher for study of said prediction coefficient including a prediction means which calculates a predicted

value of said attention output data based on two or more 1st data extracted in said 1st extraction means.
The 2nd determination means that determines two or more data extracted from said student data based on the waveform characteristic of said student dataThe 2nd extraction means that extracts two or more 2nd data from said student data according to determination in said 2nd determination means about attention teacher data which is said teacher data which is going to calculate a predicted valueA calculating means which calculates said prediction coefficient based on two or more data extracted in said 2nd extraction means.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the data processing device it enables it to raise the processing performance at the time of performing data processingsuch as image dataa data processing methodand a mediumconcerning a data processing devicea data processing methodand a medium.
[0002]
[Description of the Prior Art]This applicant has proposed class sorting adaptation processing previouslyfor example as processing for improving improvement and other picturessuch as image quality of a picture.
[0003]Class sorting adaptation processing consists of class sorting processing and adaptive processingand performs adaptive processing for data for every class part opium poppy and class by class sorting processing based on the character. Adaptive processing is a thing of the following techniques.

[0004]By namelythe thing for which the predicted value of the pixel of an original image is calculated by the linear combination of the pixel (suitably henceforth an input pixel) for which an inputted image (picture of the processing object of class sorting adaptation processing) is constituted from adaptive processingfor exampleand a predetermined prediction coefficient. The picture which removed the noise contained in the inputted imagethe picture which has improved the dotage produced in the inputted imagethe picture which raised resolutionetc. are acquired.
[0005]While using as teacher data original images (for examplethe picture which does not contain a noisea picture without dotagea high-resolution pictureetc.) nowspecificallyfor exampleThe inputted image which superimposed the noise on the original imageor added the shading off is used as student dataThe predicted value E [y] of the pixel value y of the pixel (suitably henceforth original picture matter) which constitutes an original image A set of pixel value x_1 of some input pixels (pixel which constitutes an inputted image)$x_2$and ...It considers asking by the primary linearity coupled models specified by the linear combination of

predetermined prediction coefficient $w_1 w_2$and ... In this casethe predicted value E [y] can be expressed with a following formula.
[0006]
$E[y] = w_1 x_1 + w_2 x_2 + \ldots\ldots$ (1)
Procession Y' which becomes by the procession X which becomes by the procession W which becomes by set of the prediction coefficient wand the student data aggregate in order to generalize a formula (1)and set of predicted value E [y][0007]
[Equation 1]

If a definition is come out and giventhe following observation equations will be materialized.
[0008]
XW=Y' ... (2)
In [ingredient x_{ij} of the procession X means here the j-th student data in the student data aggregate (student data aggregate used for prediction of teacher data y_i of eye i affair) of eye i affairand] a formula (1) ingredient w_j of the procession WThe prediction coefficient which a product with the j-th student data in the student data aggregate calculates is expressed. y_i expresses the teacher data of eye i affairtherefore E [y_i] expresses the predicted value of the teacher data of eye i affair.
[0009]And it considers applying a least square method to this observation equationand calculating the predicted value E [y] near the pixel value y of original picture matter. In this casethe procession E which becomes by set of the remainder e of predicted value E [y] to the procession Y which becomes by set of the true pixel value (true value) y of the original picture matter used as teacher dataand the pixel value y of original picture matter [0010]
[Equation 2]

If a definition is come out and giventhe following remainder equations will be materialized from an equation (2).
[0011]
XW=Y+E ... (3)
In this caseprediction coefficient w_i for calculating the predicted value E [y] near the pixel value y of original picture matter is a square error. [0012]
[Equation 3]

It can ask by using the minimum.
[0013]Thereforewhen what differentiated the above-mentioned square error from prediction coefficient w_i is set to 0in order that prediction coefficient w_i which fills a following formula may calculate the predicted value E [y] near the pixel value y

of original picture matterit will call it an optimum value.
[0014]
[Equation 4]

... (4)
Thena following formula is first materialized by differentiating a formula (3) from prediction coefficient w_i.
[0015]
[Equation 5]

... (5)
A formula (6) is obtained from the formula (4) and (5).
[0016]
[Equation 6]

... (6)
If the student data x in the remainder equation of an equation (3)the prediction coefficient wteacher data yand the relation of the remainder e are taken into considerationthe following normal equations can be obtained from an equation (6).
[0017]
[Equation 7]

... (7)
Each equation which constitutes the normal equation of an equation (7) is that only a certain amount of number prepares the student data x and teacher data yThe optimal prediction coefficient w can be calculated by being able to build only the same number as the number of the prediction coefficients w which should be calculatedtherefore solving a formula (7) (howeverin order to solve a formula (7)in a formula (7)the procession which comprises a coefficient concerning the prediction coefficient w needs to be Masanori). In solving a formula (7)it is possible to sweep out and touse law (elimination of Gauss-Jordan) etc. for example.
[0018]Adaptive processing calculates the optimal prediction coefficient w as mentioned aboveand calculates the predicted value E [y] near the pixel value y of original picture matter by a formula (1) further using the prediction coefficient w.
[0019]Although adaptive processing is not included in an inputted imageit is the point that the ingredient contained in an original image is reproducedand differs from mere interpolation processingfor example. Namelyin adaptive processingas long as a formula (1) is seenit is the same as that of the interpolation processing what is called using an interpolation filterbut. Since [for which the prediction coefficient w equivalent to the tap coefficient of the interpolation filter uses

teacher data y] it asks by study so to speakthe ingredient contained in an original image is reproducible. As adaptive processing can be called processing whichso to speakhas a creation (resolution imagination) operation of a picture and being mentioned above from thisThe predicted value of the original image which removed a noise and dotage from the inputted image is calculatedand also when changing the picture of a low resolution or standard resolution into the picture of high resolutionit can usefor example.

[0020]

[Problem(s) to be Solved by the Invention]As mentioned abovein class sorting adaptation processingadaptive processing is performed for every classbut. Original picture matter which is going to calculate a predicted value in the class sorting performed in the preceding paragraph (original picture matter) Since it does not necessarily actually exist other than the time of studyhereIt observes for being assumingtwo or more input pixels around the position of the noticed picture element are extractedand the class division of the noticed picture element is carried out based on the character (for examplethe pattern of the pixel value which are two or more of the input pixelsthe inclination of a pixel valueetc.). And as two or more input pixels used for this class sortingit sees from a noticed picture element and the input pixel in a fixed position is extracted.

[0021]Howeverin the case where an inputted image with dotage is changed into the picture which has improved the dotage by class sorting adaptation processingfor example etc.Regardless of the degree of dotage of the inputted imageit sees from a noticed picture elementand if the input pixel in a fixed position was used for the class sorting of the noticed picture elementclass part [which fully reflected the character of the noticed picture element] being injured may become difficult.

[0022]That iswhenperforming class sorting adaptation processing for an inputted image with the small degree of dotage (degree of dotage) for exampleit can see from a noticed picture element and the direction which performs class sorting using the input pixel in a comparatively near position can perform the class division which fully reflected the character of the noticed picture element. When performing class sorting adaptation processing for an inputted image with the large degree of dotageit can see from a noticed picture element and the direction which performs class sorting using the input pixel in a comparatively far position can perform the class division which fully reflected the character.

[0023]For examplewhen the inputted image of the peripheral part of the position of a noticed picture element is flatthe class division in which the direction which performs class sorting using the input pixel in the wide range of the inputted image in which a certain amount of change is seen fully reflected the character of the noticed picture element can be performed.

[0024]Thereforesee from a noticed picture elementand if the input pixel in a fixed position was used for the class sorting of the noticed picture elementThe picture which has fully improved the inputted image may not be acquired according to the thing which fully reflected the character of the noticed picture element and which

it cannot be injured by a class and the processing performance of class sorting adaptation processing deteriorates as a resulti.e.class sorting processing.
[0025]Although it sees from a noticed picture elementand the linear prediction type of a formula (1) calculates and the predicted value which is a noticed picture element is calculated also by adaptive processing using the input pixel in a fixed positionIt is expected that see from a noticed picture element and the small predicted value of a prediction error [as opposed to a noticed picture element in the direction which calculated the linear prediction type of the formula (1)] is calculated like the case in class sorting also in this case using the input pixel in a variable position if needed.
[0026]This invention is made in view of such a situationfor exampleit enables it to raise processing performancessuch as class sorting adaptation processing.
[0027]
[Means for Solving the Problem]This invention is characterized by the 1st data processing device comprising the following.
A determination means to determine two or more data extracted from input data based on the waveform characteristic of input data.
An extraction means to extract two or more data from input data about attention output data which is output data which is going to calculate a predicted value according to determination in a determination means.
A prediction means which calculates a predicted value of attention output data based on two or more data extracted in an extraction means.

[0028]In the 1st data processing devicebased on two or more data extracted in an extraction meansA class sorting means to perform class sorting about attention output dataand to output a corresponding class code can be formed furtherand a prediction means can be made to be asked for a predicted value of attention output data in this case using a predetermined prediction coefficient corresponding to a class code.
[0029]A prediction means can be made to linearity-primary-predict attention output data using a prediction coefficient. A prediction means can be made to linearity-primary-predict attention output data using a prediction coefficient and two or more data extracted in an extraction means.
[0030]A prediction coefficient memory measure which has memorized a prediction coefficient can be further provided in the 1st data processing device for every class code.
[0031]A determination means can be made to be able to detect an extremum of input dataand two or more data extracted from input data can be made to determine it as it based on the detection result. A determination means can be made to be able to calculate a difference value of input dataand two or more data extracted from input data can be made to determine it as it based on the result of an operation. A determination means can be made to be able to calculate an error of input data to a function which approximates input dataand two or more data extracted from input data can be made to determine it as it based on the result of

an operation.
[0032]Input data and output data can be made into image data. An extraction means can be made to extract a pixel which exists on the outskirts spatially or in time from image data as input data to a pixel as attention output data in this case.
[0033]This invention is characterized by the 1st data processing method comprising the following.
A determination step which determines two or more data extracted from input data based on the waveform characteristic of input data.
An extraction step which extracts two or more data from input data about attention output data which is output data which is going to calculate a predicted value according to determination in a determination step.
A prediction step which calculates a predicted value of attention output data based on two or more data extracted in an extraction step.

[0034]This invention is characterized by a program which a computer is made to execute comprising the following in the 1st medium.
A determination step which determines two or more data extracted from input data based on the waveform characteristic of input data.
An extraction step which extracts two or more data from input data about attention output data which is output data which is going to calculate a predicted value according to determination in a determination step.
A prediction step which calculates a predicted value of attention output data based on two or more data extracted in an extraction step.

[0035]This invention is characterized by the 2nd data processing device comprising the following.
A creating means which generates student data which serves as a student from teacher data which serves as a teacher for study of a prediction coefficient.
A determination means to determine two or more data extracted from student data based on the waveform characteristic of student data.
An extraction means to extract two or more data from student data about attention teacher data which is teacher data which is going to calculate a predicted value according to determination in a determination means.
A calculating means which calculates a prediction coefficient based on two or more data extracted in an extraction means.

[0036]In the 2nd data processing devicebased on two or more data extracted in an extraction meansA class sorting means to perform class sorting about attention teacher dataand to output a corresponding class code can be formed furtherand a calculating means can be made to be asked for a prediction coefficient for every class code in this case using two or more data extracted in an extraction means.
[0037]A calculating means can be made to be asked for a prediction coefficient for teacher data to be obtained by linearity primary prediction. A calculating means can be made to be asked for a prediction coefficient for teacher data to be

obtained by linearity primary prediction using two or more data extracted in an extraction means.
[0038]A determination means can be made to be able to detect an extremum of student dataand two or more data extracted from student data can be made to determine it as it based on the detection result. A determination means can be made to be able to calculate a difference value of student dataand two or more data extracted from student data can be made to determine it as it based on the result of an operation. A determination means can be made to be able to calculate an error of student data to a function which approximates student dataand two or more data extracted from student data can be made to determine it as it based on the result of an operation.
[0039]Student data and teacher data can be made into image data. In this casean extraction means can be made to extract a pixel which exists on the outskirts spatially or in time from image data as student data to a pixel as attention teacher data.
[0040]This invention is characterized by the 2nd data processing method comprising the following.
A generation step which generates student data which serves as a student from teacher data which serves as a teacher for study of a prediction coefficient.
A determination step which determines two or more data extracted from student data based on the waveform characteristic of student data.
An extraction step which extracts two or more data from student data about attention teacher data which is teacher data which is going to calculate a predicted value according to determination in a determination step.
An arithmetic step which calculates a prediction coefficient based on two or more data extracted in an extraction step.

[0041]This invention is characterized by a program which a computer is made to execute comprising the following in the 2nd medium.
A generation step which generates student data which serves as a student from teacher data which serves as a teacher for study of a prediction coefficient.
A determination step which determines two or more data extracted from student data based on the waveform characteristic of student data.
An extraction step which extracts two or more data from student data about attention teacher data which is teacher data which is going to calculate a predicted value according to determination in a determination step.
An arithmetic step which calculates a prediction coefficient based on two or more data extracted in an extraction step.

[0042]This invention is characterized by the 3rd data processing device comprising the following.
The 1st determination means that determines two or more data extracted from input data based on the waveform characteristic of input data.
The 1st extraction means that extracts two or more 1st data from input data

about attention output data which is output data which is going to calculate a predicted value according to determination in the 1st determination means.
A prediction means which calculates a predicted value of attention output data based on two or more 1st data extracted in the 1st extraction means.
A creating means which generates student data which serves as a student from teacher data which serves as a teacher for study of a prediction coefficientThe 2nd determination means that determines two or more data extracted from student data based on the waveform characteristic of student dataA calculating means which calculates a prediction coefficient about attention teacher data which is teacher data which is going to calculate a predicted value based on two or more data extracted in the 2nd extraction means that extracts two or more 2nd data from student dataand the 2nd extraction means according to determination in the 2nd determination means.

[0043]In the 1st data processing device of this inventiona data processing methodand a mediumBased on the waveform characteristic of input datatwo or more data extracted from input data is determinedand two or more data is extracted from input data about attention output data which is output data which is going to calculate a predicted value according to the determination. And a predicted value of attention output data is calculated based on two or more of the extracted data.
[0044]In the 2nd data processing device of this inventiona data processing methodand a mediumstudent data which serves as a student is generated from teacher data which serves as a teacher for study of a prediction coefficientand two or more data extracted from student data is determined based on the waveform characteristic of the student data. And about attention teacher data which is teacher data which is going to calculate a predicted value according to the determinationtwo or more data is extracted from student dataand a prediction coefficient is calculated based on two or more of the extracted data.
[0045]In the 3rd data processing device of this inventionbased on the waveform characteristic of input datatwo or more data extracted from input data is determinedand two or more 1st data is extracted from input data about attention output data which is output data which is going to calculate a predicted value according to the determination. And a predicted value of attention output data is calculated based on two or more of the 1st extracted data. On the other handstudent data which serves as a student is generated from teacher data which serves as a teacher for study of a prediction coefficientand two or more data extracted from student data is determined based on the waveform characteristic of the student data. And about attention teacher data which is teacher data which is going to calculate a predicted value according to the determinationtwo or more 2nd data is extracted from student dataand a prediction coefficient is calculated based on two or more of the extracted data.
[0046]
[Embodiment of the Invention]Drawing 1 shows the example of composition of the

1 embodiment of the image processing device which applied this invention.
[0047]In this image processing deviceif SD (Standard Density) picture with low resolution is inputted as an inputted image for exampleby performing class sorting adaptation processing to that inputted imageThe picture (HD (High Density) picture) of high resolution is outputted.
[0048]Namelythis image processing device comprises frame memory 1class tap generating circuit 2prediction tap generating circuit 3class sorting circuit 4and coefficient RAM(Random Access Memory) 5the prediction arithmetic circuit 6and the tap determining circuit 7and thereThe inputted image (SD picture) used as the object which improves resolution is inputted.
[0049]The frame memory 1 is made as [store /for example / the inputted image inputted into an image processing device / temporarily / per frame]. At this embodimentthe frame memory 1 can perform the processing in real timeeven if the inputted image which can memorize the inputted image of a multiple frame now with a bank changeand is inputted into an image processing device by this is an animation.
[0050]Original picture matter which the class tap generating circuit 2 tends to ask for a predicted value by class sorting adaptation processing (here) The input pixel which uses the pixel of a high-resolution HD image for the class sorting about the noticed picture element as a noticed picture elementAccording to the tap information from the tap determining circuit 7it extracts from the inputted image memorized by the frame memory 1and this is outputted to the class sorting circuit 4 as a class tap.
[0051]The input pixel used for the prediction tap generating circuit 3 calculating the predicted value of a noticed picture element in the prediction arithmetic circuit 6According to the tap information from the tap determining circuit 7it extracts from the inputted image memorized by the frame memory 1and is made as [supply / the prediction arithmetic circuit 6] by making this into a prediction tap.
[0052]Based on the class tap from the class tap generating circuit 2the class sorting circuit 4 carries out class sorting of the noticed picture elementand is made as [give / to coefficient RAM5 / the class code corresponding to the class obtained as a result / as an address]. Namelythe class sorting circuit 4 the class tap from the class tap generating circuit 2For example1-bit ADRC (Adaptive Dynamic Range Coding) processing is carried outand the ADRC code obtained as a result is outputted to coefficient RAM5 as a class code.
[0053]In K bit ADRC processingthe maximum MAX and the minimum MIN of a pixel value of an input pixel which constitute a class tap are detected herefor exampleDR=MAX-MIN is used as the local dynamic range of a setand re quantization of the input pixel which constitutes a class tap is carried out to K bit based on this dynamic range DR. That isout of the pixel value of the pixel which constitutes a class tapthe minimum MIN is subtracted and division (quantization) of the subtraction value is done by $DR/2^K$. Thereforewhen 1-bit ADRC processing of the class tap is carried outthe pixel value of each input pixel which constitutes

the class tap will be 1 bit. And the bit string which put in order the pixel value of 1 bit about each pixel which constitutes a class tap acquired by making it above in this case in predetermined order is outputted as an ADRC code.

[0054]If coefficient RAM5 has memorized the prediction coefficient for every class obtained by performing study in the learning device mentioned later and a class code is supplied from the class sorting circuit 4The prediction coefficient memorized to the address corresponding to the class code is readand the prediction arithmetic circuit 6 is supplied.

[0055]The prediction coefficient w about the class of a noticed picture element to which the prediction arithmetic circuit 6 is supplied from coefficient RAM5$w_2$and ...By performing the operation shown in the formula (1) using prediction tap (pixel value of each pixel to constitute) x_1 from the prediction tap generating circuit 3$x_2$and ...the predicted value E [y] of the noticed picture element y is calculatedand this is outputted as a pixel value of the pixel which has improved resolution.

[0056]Based on the waveform characteristic of the inputted image memorized by the frame memory 1the tap determining circuit 7The input pixel which makes a class tap and a prediction tap constitute is determinedand the information (suitably henceforth tap information) about the input pixel which makes the class tap and prediction tap constitute is supplied to the class tap generating circuit 2 and the prediction tap generating circuit 3.

[0057]That isthe tap determining circuit 7 is a central pixel (here) about the input pixel in the position of a noticed picture elementfor exampleas a dotted line surrounds and shows to drawing 2. For examplesquare-like the class tap and prediction tap which horizontal x length becomes at 5x5 pixels as meaning the pixel in the position of the center of gravityfor example. It assumes as a fundamental tap (suitably henceforth a basic tap) which makes a class tap generating circuit and the prediction tap generating circuit 3 constitute (both are summarized and it is only hereafter called a tap suitably).

[0058]Herein drawing 2x seal shows the pixel (HD picture element) which constitutes an HD imageand O seal shows the pixel (SD pixel) which constitutes SD picture as an inputted image. Thereforein drawing 2SD picture is what set the pixel number of the side of an HD imageand each length to one half.

[0059]If a basic tap is assumedthe tap determining circuit 7 will detect the direction which passes along other SD pixels (input pixel) of a basic tap by making the central pixel into the starting pointfor exampleas shown in drawing 3. Hereas a basic tap is mentioned abovewhen it comprises 5x5 pixelsas shown in drawing 3direction D_1 of 16 thru/or D_{16} which makes a central pixel the starting point will be detected.

[0060]The tap determining circuit 7 determines SD pixel which makes a tap constitute eventually based on the waveform characteristic (characteristic of a pixel value) of SD pixel which exists in the direction about Dfor all directions $_i$ (here i= 12...16). That isabout Dfor all directions $_i$based on the waveform characteristic of SD picture which exists in the directionas shown in drawing 4the

position of SD pixel which constitutes the tap which exists in the direction is moved. And the tap determining circuit 7 supplies the information about the position of SD pixel which will constitute a tap eventually as tap information to the class tap generating circuit 2 and the prediction tap generating circuit 3 as a result of the movement.

[0061]Nextwith reference to the flow chart of drawing 5the resolution improvement processing performed in the image processing device of drawing 1 in which the resolution of an inputted image is improved is explained.

[0062]To the frame memory 1SD picture (video) which is an object of resolution improvement processing is supplied one by one per frame as an inputted imageand the inputted image supplied per frame such is memorized one by one in the frame memory 1.

[0063]And the predetermined HD picture element which is going to calculate a predicted value is made into a noticed picture elementand in Step S1 the tap determining circuit 7Based on the waveform characteristic of the inputted image memorized by the frame memory 1the input pixel which makes the tap about a noticed picture element constitute is determinedand the tap information about the position of the input pixel is outputted to the class tap generating circuit 2 and the prediction tap generating circuit 3.

[0064]The class tap generating circuit 2 or the prediction tap generating circuit 3In [if tap information is received from the tap determining circuit 7] Step S2According to the tap informationthe input pixel which makes the class tap or prediction tap about a noticed picture element which is going to calculate a predicted value constitute is read from the frame memory 1and this constitutes a class tap or a prediction taprespectively. This class tap or prediction tap is supplied to the class sorting circuit 4 or the prediction arithmetic circuit 6respectively.

[0065]If a class tap is received from the class tap generating circuit 2in Step S3based on the class tapthe class sorting circuit 4 will perform class sortingand will output as an address the class code obtained as a result to coefficient RAM5 about a noticed picture element. In step S4coefficient RAM5 reads the prediction coefficient memorized to the address corresponding to the class code from the class sorting circuit 4and it supplies it to the prediction arithmetic circuit 6.

[0066]In Step S5by performing the operation of the linear prediction type showing in a formula (1) using the prediction tap from the prediction tap generating circuit 3and the prediction coefficient from coefficient RAM5the predicted value E [y] of the noticed picture element (HD picture element) y is calculatedand it progresses to Step S6 in the prediction arithmetic circuit 6. In Step S6the prediction coefficient arithmetic circuit 6 outputs the predicted value E [y] of the noticed picture element y for which it asked at Step S5 as an HD picture element which has improved resolutionand it progresses to Step S7.

[0067]It is judged whether the predicted value of all the HD picture elements which constitute the frame of a noticed picture element from Step S7 was calculatedWhen judged with not having asked yetit returns to Step S1 and the

processing after Step S1 is newly repeated as a noticed picture element in the HD picture element which has not been asked for a predicted value yet.

[0068]When judged with the predicted value of all the HD picture elements which constitute the frame of a noticed picture element having been calculated in Step S7It progresses to Step S8 and it is judged whether the inputted image (SD picture) corresponding to the frame of the HD image which should be processed next is memorized by the frame memory 1. In Step S8the inputted image corresponding to the frame of the HD image which should be processed nextWhen judged with the frame memory 1 memorizingin the predetermined HD picture element of the frame of the HD image which should be processed to the nextas a noticed picture elementit returns to Step S1 and the same processing is newly repeated hereafter.

[0069]On the other handin Step S8when the inputted image corresponding to the frame of the HD image which should be processed next is judged as the frame memory 1 not memorizingresolution improvement processing is ended.

[0070]Nextwith reference to the flow chart of drawing 6a 1st embodiment of the tap decision processing in Step S1 of drawing 5 performed in the tap determining circuit 7 is described.

[0071]It is hereafter called a tap suitably one by one [its / pixel] besides the whole set of SD pixel used for the operation of class sorting and the linear prediction type of a formula (1).

[0072]In the tap determining circuit 7a basic tap is set up in Step S11. Namelyin Step S11as the dotted line surrounded and showed to drawing 2the tap which horizontal x length becomes at 5x5 pixels is set up as a basic tap by making the input pixel in the position of a noticed picture element into a central pixel.

[0073]And it progresses to Step S12and as shown in drawing 3direction D_1 of 16 thru/or D_{16} which passes along other SD pixels of a basic tap is detected by making a central pixel into the starting pointand it progresses to Step S13.

[0074]The variable i which expresses with Step S13 direction D_1 of 16 thru/or D_{16} detected at Step S12 is initialized by 1for exampleand progresses to Step S14and the variable j showing the tap on Dfor all directions $_i$ is initialized by 1for exampleand progresses to Step S15.

[0075]In Step S15it is judged whether SD pixel (pixel value) which is tap $T_{i \text{ in the j-th}}$ $_{\text{and j}}$ from the central pixel on direction D_i serves as an extremum. When judged with SD pixel used as tap $T_{i \text{ and j}}$ not serving as an extremum in Step S15progress to Step S16 and Tap $T_{i \text{ on direction Diand j}}$The tap outside it (direction which is not a central pixel side) is moved to the position which separated only 1 pixel from the central pixelfor example. And it returns to Step S15 and the same processing is repeated hereafter.

[0076]In Step S15when judged with SD pixel used as tap $T_{i \text{ and j}}$ serving as an extremumit progresses to Step S17and it **********s only 1 and the variable j progresses to Step S18. It is judged whether it is below pixel number J_i which constitutes taps other than a central pixel which have the variable j on direction D_i from Step S18.

[0077]Herefor example in drawing 3direction $D_1D_3D_5...J_i$ about D_{15} are 2and direction $D_2D_4D_6...J_i$ about D_{16} are 1.
[0078]When judged with it being below pixel number J_i which constitutes taps other than a central pixel which have the variable j on direction D_i in Step S18That iswhen all the SD pixels that constitute taps other than a central pixel on direction D_i have not been supposed that the extremum is taken yetit returns to Step S15 and the same processing is repeated for tap $T_{i \text{ in the position of SD pixel which is not the extremumand j}}$.
[0079]. In Step S18the variable j is on direction D_i. When judged with it not being below pixel number J_i which constitutes taps other than a central pixel (i.e.when all the SD pixels that constitute taps other than a central pixel on direction D_i are presupposed that the extremum is taken)it progresses to Step S19 and **********s the variable i only for 1. And it progresses to Step S20 and it is judged whether the variable i is below the total I of the direction detected at Step S12 (the embodiment of drawing 3 16).
[0080]In Step S20when judged with the variable i being below I (i.e.when SD pixel used as an extremum is used as the tap yet about no directions detected at Step S12)it returns to Step S14 and the same processing is repeated hereafter.
[0081]When it is judged with the variable i not being below I in Step S20 on the other handNamelywhen SD pixel used as an extremum is used as a tap about all the directions detected at Step S12progress to Step S21 and the information about the position of SD pixel which constitutes the tap now as tap informationIt is outputted to the class tap generating circuit 2 and the prediction tap generating circuit 3and a return is carried out.
[0082]According to a 1st embodiment of the above tap decision processingsin the class tap generating circuit 2 and the prediction tap generating circuit 3a tap as shown in drawing 7 will be constituted.
[0083]That isdrawing 7 (also setting to drawing 9 and drawing 11 which are mentioned later the same) shows SD pixel in the direction D_1 and direction D_9 opposite to it 180 degrees for examplepaying attention to direction D_1 of the directions of 16 shown in drawing 3.
[0084]In drawing 7 (also setting to drawing 9 and drawing 11 the same). While expressing with n the position of the central pixel which constitutes a tap and expressing with n−m further the position of the pixel which only m pixel (m is a positive integer) has in the direction of D_1 from the position nthe position of the pixel which only m pixel has in the direction of D_9 from the position n is expressed with n+m.
[0085]In drawing 7 (also setting to drawing 9 and drawing 11 the same)x seal shows SD pixel (pixel value)and O seal shows the tap (SD pixel which has become).
[0086]Two SD pixels by which two SD pixels which adjoin in the direction about direction D_1 adjoin in the direction also about direction D_9 again serve as a tap to SD pixel which drawing 7 (A) shows the basic taptherefore is a central pixel.
[0087]Drawing 7 (B) to SD pixel which shows the tap constituted by the tap decision processing of drawing 6and is a central pixel from the basic tap of drawing 7 (A) about direction D_1. SD pixel which SD pixel used as the maximal value which

appears first in accordance with the directionand SD pixel used as the minimal value serve as a tapand serves as the minimal value first expressed in accordance with the direction also about direction $D_9$and SD pixel used as the maximal value serve as a tap.

[0088]Nextwith reference to the flow chart of drawing 8a 2nd embodiment of the tap decision processing in Step S1 of drawing 5 performed in the tap determining circuit 7 is described.

[0089]In Step S31 or S32in the tap determining circuit 7the respectively same processing as the case in Step S11 or S12 of drawing 6 is performedand by thisDetection of direction D_1 of 16 thru/or D_{16} which passes along SD pixel of setting out of a basic tap and everything but the basic tap which makes a central pixel the starting point is performed.

[0090]And progress to Step S33 and like the case in Step S13 of drawing 6The variable i showing the direction detected at Step S32 is initialized by 1for exampleand progresses to Step S34and dynamic range DR_i of SD pixel used as the tap on direction D_i calculates. That isin Step S34the maximum and the minimum (the greatest pixel value and the minimum pixel value) are detected out of all (a central pixel is included) SD pixels used as the tap on direction $D_i$and the difference of the maximum and minimum is called for as dynamic range DR_i.

[0091]After calculation of dynamic range DR_iit progresses to Step S35 and it is judged from the threshold th to which the dynamic range DR_i was set beforehand whether it is size. When judged with dynamic range DR_i being below the threshold th in Step S35among SD pixels used as the tap on direction D_iWhen there is no so big changetherefore stationarity is observed in the tap on direction $D_i$it progresses to Step S36and SD pixel which constitutes a tapexcluding a central pixelis changed so that the interval of the taps on direction D_i may spread by 1 pixelfor example. And it progresses to Step S34 and the same processing is repeated hereafter.

[0092]Among SD pixels which serve as a tap on direction D_i when judged with dynamic range DR_i being size from the threshold th in Step S35When it is admited that there is a comparatively big changetherefore there is no stationarity in the tap on direction $D_i$it progresses to Step S37 and **********s the variable i only 1. And it progresses to Step S38 and it is judged whether the variable i is below the total I of the direction detected at Step S32.

[0093]When judged with the variable i being below I in Step S38That isabout all the directions detected at Step S32when SD pixel which a dynamic range consists large of from the threshold th has not been used as the tap yetit returns to Step S34 and the same processing is repeated hereafter.

[0094]When it is judged with the variable i not being below I in Step S38 on the other handNamelywhen SD pixel which a dynamic range consists large of from the threshold th is used as a tap about all the directions detected at Step S32It progresses to Step S39and nowas tap informationthe information about the position of SD pixel which constitutes the tap is outputted to the class tap generating circuit 2 and the prediction tap generating circuit 3and carries out a

return.
[0095]According to a 2nd embodiment of the above tap decision processingsin the class tap generating circuit 2 and the prediction tap generating circuit 3a tap as shown in drawing 9 will be constituted.
[0096]Namelydrawing 9 (A) to SD pixel which shows the basic taptherefore is a central pixel like drawing 7 (A) about direction D_1. Two SD pixels by which two SD pixels which adjoin in the direction adjoin in the direction also about direction D_9 again serve as a tap.
[0097]Drawing 9 (B) is shown from the basic tap of drawing 9 (A)and the tap constituted by the tap decision processing of drawing 8 about both direction D_1 and D_9. SD pixel which makes dynamic range DR_1 and DR_9 larger than the threshold th serves as a tap.
[0098]In the embodiment of drawing 8 and drawing 9extended the interval of SD pixels used as a tap so that dynamic range DR_i which is the difference of the maximum of the SD pixels used as the tap on direction D_i and the minimum might become large from the threshold thbut. In additionit is possible to extend the interval of SD pixels used as a tap etc. so that the difference of what SD pixel which serves as a tap on direction $D_i$for example adjoins may become large from the threshold th.
[0099]Nextwith reference to the flow chart of drawing 10a 3rd embodiment of the tap decision processing in Step S1 of drawing 5 performed in the tap determining circuit 7 is described.
[0100]In the tap determining circuit 7the respectively same processing as the case in Steps S11 thru/or S13 of drawing 6 is performed in Steps S41 thru/or S43. Therebydetection of direction D_1 of 16 which passes along other SD pixels of the basic tap which makes the starting point setting out of a basic tap and a central pixel thru/or $D_{16}$and initialization showing the detected direction of the variable i are performed.
[0101]And it progresses to Step S44and for examplestraight-line (suitably henceforth approximation straight lines) L_i as a function which approximates SD pixel (pixel value) used as the basic tap on direction D_i is called forand it progresses to Step S45. SD pixel (a central pixel is included) which serves as a tap on direction D_i in Step S45 -- the error (for examplesquare error) over each approximation-straight-lines L_i is searched forand the integrated value of the error is calculated further. And it progresses to Step S46 and it is judged whether the integrated value of the error is size from a predetermined threshold.
[0102]When it judges that an integrated value with error is not size from a predetermined threshold in Step S46among SD pixels used as the tap on direction D_iWhen there is no so big change and stationarity is acceptedit progresses to Step S47 and all taps other than a central pixel on direction D_i are moved by 1 pixel along with the direction D_i (on outside). And it progresses to Step S45 and the same processing is repeated hereafter.
[0103]Among SD pixels which serve as a tap on direction D_i when judged with an integrated value with error being size from a predetermined threshold in Step

S46When there is a comparatively big change and stationarity is not acceptedit progresses to Step S48 and **********s the variable i only 1. And it progresses to Step S49 and it is judged whether the variable i is below the total I of the direction detected at Step S42.

[0104]In Step S49when judged with the variable i being below Inamelywhen SD pixel which an integrated value with error consists large of from a predetermined threshold is used as the tap yet about no directions detected at Step S42it returns to Step S44 and the same processing is repeated hereafter.

[0105]When it is judged with the variable i not being below I in Step S49 on the other handNamelywhen SD pixel which an integrated value with error consists large of from a predetermined threshold about all the directions detected at Step S42 is used as a tapIt progresses to Step S50and as tap informationthe information about the position of SD pixel which constitutes the tap now is outputted to the class tap generating circuit 2 and the prediction tap generating circuit 3and carries out a return.

[0106]According to a 3rd embodiment of the above tap decision processingsin the class tap generating circuit 2 and the prediction tap generating circuit 3a tap as shown in drawing 11 will be constituted.

[0107]Namelydrawing 11 (A) to SD pixel which shows the basic taptherefore is a central pixel like drawing 7 (A) about direction D_1. Two SD pixels by which two SD pixels which adjoin in the direction adjoin in the direction also about direction D_9 again serve as a tap.

[0108]Drawing 11 (B) is shown from the basic tap of drawing 11 (A)and the tap constituted by the tap decision processing of drawing 10 about both direction D_1 and D_9. SD pixel which makes the integrated value of the error over approximation-straight-lines L_1 and L_9 larger than a predetermined threshold serves as a tap.

[0109]Although SD pixel to straight-line L_i which approximates SD pixel used as a basic tap on direction D_i which makes a tap constitute based on the integrated value of the error of SD pixel which constitutes a tap was determined in the embodiment of drawing 10 and drawing 11In additionit is also possible todetermine SD pixel which makes a tap constitute for examplebased on distribution with error etc.

[0110]Although all taps other than a central pixel on direction D_i were moved by 1 pixel along with the direction D_i in Step S47 in the embodiment of drawing 10It may be made to move a tap in addition to thisin Step S47for example so that the interval of the taps on direction D_i may be extendedfor example by 1 pixel.

[0111]Although it asks for a straight line and the tap was determined in the embodiment of drawing 10 and drawing 11 based on the error over the straight line as a function which approximates SD pixel used as a basic tap on direction D_iIn additionit is also possible to search for the flat surface and curved surface which are a function which approximates SD pixel used as a basic tap which exists in the two or more directionsfor exampleand to determine a tap based on the error over the flat surface and curved surface.

[0112]Nextdrawing 12 shows the example of composition of the 1 embodiment of the learning device which calculates the prediction coefficient for every [coefficient RAM5 of drawing 1 is made to memorize] class.
[0113]The original image (HD image high-resolution here) used as teacher data y is supplied to the frame memory 61 per framefor exampleand the frame memory 61 stores the original image temporarily at it. The infanticide circuit 62 generates SD picture with low resolution as student data by reading the original image set to teacher data y in the study of a prediction coefficient memorized by the frame memory 61and thinning out the pixel number which constitutes the original image. The seal 3 and the infanticide circuit 62 generate SD pixel similarly shown in drawing 2 by O seal byfor examplethinning out the pixel number of the width and length of an HD image shown in drawing 2 by x seal to one halfrespectively. This SD picture is supplied to the frame memory 63.
[0114]The frame memory 63 stores temporarily SD picture from the infanticide circuit 62. The frame memories 61 and 63 are constituted like the frame memory 1 of drawing 1.
[0115]The class tap generating circuit 64 or the prediction tap generating circuit 65SD pixel which constitutes SD picture memorized by the frame memory 63 is usedLike the class tap generating circuit 2 of drawing 1or the prediction tap generating circuit 3According to the tap information from the tap determining circuit 72about the teacher data used as a noticed picture elementa class tap or a prediction tap is constituted and the class sorting circuit 66 or the adder circuit 67 is suppliedrespectively. A prediction tap is supplied also to the adder circuit 67.
[0116]The class sorting circuit 66 is constituted like the class sorting circuit 4 of drawing 1Based on the class tap from the class tap generating circuit 64class sorting of the noticed picture element is carried outand a corresponding class code is given as an address to the prediction tap memory 68 and the teacher data memory 70.
[0117]The adder circuit 67 reads the memory value of the address corresponding to the class code which the class sorting circuit 66 outputs from the prediction tap memory 68and The memory valueThe operation equivalent to the summation (sigma) which serves as a multiplier of the prediction coefficient w in the left side of the normal equation of an equation (7) by adding SD pixel (pixel value) which constitutes the prediction tap from the prediction tap generating circuit 65 is performed. And the adder circuit 67 is made to memorize in the form which overwrites the result of an operation to the address corresponding to the class code which the class sorting circuit 66 outputs.
[0118]The prediction tap memory 68 memorizes the output value of the adder circuit 67 to the address while it reads the memory value of the address corresponding to the class which the class sorting circuit 66 outputs and supplies it to the adder circuit 67.
[0119]While reading the noticed picture element of the original picture matter which constitutes the original image memorized by the frame memory 61 as teacher data ythe adder circuit 69By adding teacher data (original picture matter)

y which read the memory value of the address corresponding to the class code which the class sorting circuit 66 outputs from the teacher data memory 70and read it from the memory value and the frame memory 61. The operation equivalent to the summation (sigma) in the right-hand side of the normal equation of an equation (7) is performed. And the adder circuit 69 is made to memorize in the form which overwrites the result of an operation to the address corresponding to the class code which the class sorting circuit 66 outputs.

[0120]The multiplication in a formula (7) is also performed in the adder circuits 67 and 69. That isin the adding machine 67the multiplication of the SD pixel x and teacher data y which the multiplication of SD pixel x which constitute a prediction tap is also performedand constitute a prediction tap from the adding machine 69 is also performed. Thereforealthough the SD pixel x which constitutes a prediction tap is needed in the adding machine 69this is supplied from the prediction tap generating circuit 65 as mentioned above.

[0121]The teacher data memory 70 memorizes the output value of the adder circuit 69 to the address while it reads the memory value of the address corresponding to the class code which the class sorting circuit 66 outputs and supplies it to the adder circuit 69.

[0122]the arithmetic circuit 71 -- the prediction tap memory 68 or the teacher data memory 70 -- from each. The prediction coefficient for every class is calculated by reading the memory value memorized to the address corresponding to each class code one by onebuilding the normal equation showing in an equation (7)and solving this. namelythe arithmetic circuit 71 -- the prediction tap memory 68 or the teacher data memory 70 -- the prediction coefficient for every class is calculated by building the normal equation of an equation (7) and solving this from the memory value memorized to the address corresponding to each class code of each.

[0123]The tap determining circuit 72 is performing the same tap decision processing as the tap determining circuit 7 of drawing 1The tap information about the tap which the class tap generating circuit 64 and the prediction tap generating circuit 65 are made to generate is determinedand the class tap generating circuit 64 and the prediction tap generating circuit 65 are supplied.

[0124]Nextwith reference to the flow chart of drawing 13the learning processing which is performed in the learning device of drawing 12 and which calculates the prediction coefficient for every class is explained.

[0125]The HD image as an original image (video) used as teacher data is supplied to a learning device per frameand the HD image is memorized one by one in the frame memory 61. And in Step S61the HD image as an original image memorized by the frame memory 61 is supplied to the infanticide circuit 62and let it be SD picture there. As student datafrom the infanticide circuit 62this SD picture is supplied to the frame memory 63and is memorized.

[0126]And in [the tap determining circuit 72 makes the predetermined HD picture element of the frame of the HD image corresponding to the frame of SD picture memorized by the frame memory 63 a noticed picture elementand] Step S62SD

pixel which makes the tap about the noticed picture element constitute is determined like the case in the tap determining circuit 7 of drawing 1and the tap information about the SD pixel is outputted to the class tap generating circuit 64 and the prediction tap generating circuit 65.
[0127]In the class tap generating circuit 64 or the prediction tap generating circuit 65. In Step S63according to the tap information from the tap determining circuit 72SD pixel which makes the class tap or prediction tap about a noticed picture element constitute is read from the frame memory 63and a class tap or a prediction tap is constitutedrespectively. And a class tap is supplied to the class sorting circuit 66and a prediction tap is supplied to the adder circuits 67 and 69.
[0128]In the class sorting circuit 66it is made to be the same as that of the case in the class sorting circuit 4 of drawing 1 in Step S64Class sorting of the noticed picture element is carried out using the class tap from the class tap generating circuit 64and the class code as the class sorting result is given as an address to the prediction tap memory 68 and the teacher data memory 70.
[0129]And it progresses to Step S65 and an add lump of a prediction tap (student data) and teacher data is performed.
[0130]Namelyin Step S65the prediction tap memory 68 reads the memory value of the address corresponding to the class code which the class sorting circuit 66 outputsand supplies it to the adder circuit 67. The adder circuit 67 performs the operation equivalent to the summation (sigma) used as the multiplier of the prediction coefficient in the left side of the normal equation of an equation (7) using the memory value supplied from the prediction tap memory 68and SD pixel which constitutes a supplying–from prediction tap generating circuit 65 prediction tap. And the adder circuit 67 is made to memorize in the form which overwrites the result of an operation to the address of the prediction tap memory 68 corresponding to the class code which the class sorting circuit 66 outputs.
[0131]In Step S65the teacher data memory 70 reads the memory value of the address corresponding to the class code which the class sorting circuit 66 outputsand supplies it to the adder circuit 69. From the frame memory 61the adder circuit 69 reads a noticed picture elementand performs the operation equivalent to the summation (sigma) in the right–hand side of the normal equation of an equation (7) using the HD picture element used as the read noticed picture elementa prediction tapand the memory value supplied from the teacher data memory 70. And the adder circuit 69 is made to memorize in the form which overwrites the result of an operation to the address of the teacher data memory 70 corresponding to the class code which the class sorting circuit 66 outputs.
[0132]Thenall the HD picture elements which progress to Step S66 and constitute the frame of a noticed picture elementWhen it is judged whether it processed as a noticed picture element and it is judged with not having carried out yetit returns to Step S62 and the same processing is newly hereafter repeated as a noticed picture element in the HD picture element which has not been made into the noticed picture element yet.
[0133]In Step S66it is judged whether the frame of the HD image which should

progress to Step S67 and then should process all the HD picture elements which constitute the frame of a noticed picture element when judged with having processed as a noticed picture element is memorized by the frame memory 61. In Step S67when the frame of the HD image which should be processed next is judged as the frame memory 61 memorizingit returns to Step S61 and the same processing is repeated for the frame of the HD image which should be processed to the next.

[0134]The frame of the HD image which should be processed next in Step S67When judged with the frame memory 61 not memorizingnamelywhen it processes using all the HD images beforehand prepared for studyprogressing to Step S68 -- the arithmetic circuit 71 -- the prediction tap memory 68 or the teacher data memory 70 -- from each. The prediction coefficient for every class is calculated by reading the memory value memorized to the address corresponding to each class code one by onebuilding the normal equation showing in an equation (7)and solving this. In Step S69the arithmetic circuit 71 outputs the prediction coefficient for the every class for which it askedand ends learning processing.

[0135]In the learning processing of the above prediction coefficientsalthough the class from which a number required to calculate a prediction coefficient of normal equations are not obtained may ariseabout such a classit is able to make it to output a default prediction coefficient for exampleetc.

[0136]As mentioned abovesince SD pixel which makes the tap constitute was determined based on the waveform characteristic of SD pixel which constitutes a tapFor examplethe composition of the class tap for performing the class division which fully reflected the character of the noticed picture elementand the prediction tap which makes the prediction error of a predicted value small can be attainedandas a resultthe processing performance of class sorting adaptation processing can be raised.

[0137]Nexthardware can also perform a series of processings mentioned aboveand software can also perform. When software performs a series of processingsThe program which constitutes the software is installed in the computer built into the pixel processing unit and learning device as hardware for exclusive useor the general-purpose computer which performs various kinds of processings by installing various kinds of programs.

[0138]Thenthe medium used in order to install in a computer the program which performs a series of processings mentioned above and to change it into the state which can be performed by computer with reference to drawing 14 is explained.

[0139]As shown in drawing 14 (A)a user can be provided with a program in the state where it installed in the hard disk 102 and the semiconductor memory 103 as a recording medium which are built in the computer 101 beforehand.

[0140]Or as shown in drawing 14 (B)again a programThe floppy disk 111CD-ROM (Compact.) To recording mediasuch as Disc Read Only Memory112the MO (Magneto optical) disk 113DVD(Digital Versatile Disc) 114the magnetic disk 115and the semiconductor memory 116. It can store temporarily or permanently and can

provide as a software package.
[0141]Via [as a program is shown in drawing 14 (C)] the artificial satellite 122 for the digital satellite broadcasting from the download site 121In [transmit to the computer 101 on radioor transmit to the computer 123 with a cable via the networks 131such as LAN (Local Area Network) and the Internetand] the computer 101It can be made to store in the hard disk 102 etc. to build in.
[0142]The medium in this specification means the concept of a broad sense containing all these media.
[0143]The step which describes the program provided by a medium in this specificationIt is not necessary to necessarily process to a time series in accordance with the order indicated as a flow chartand a parallel target or the processing (for exampleparallel processing or processing by an object) performed individually is also included.
[0144]Nextdrawing 15 shows the example of composition of the computer 101 of drawing 14.
[0145]The computer 101 contains CPU(Central Processing Unit) 142as shown in drawing 15. Via the bus 141the input/output interface 145 is connected to CPU142 and CPU142If instructions are inputted when the input part 147 which comprises a keyboarda mouseetc. is operated by the user via the input/output interface 145According to itthe program stored in ROM(Read Only Memory) 143 corresponding to the semiconductor memory 103 of drawing 14 (A) is executed. Or a program by which CPU142 is stored in the hard disk 102A program which was transmitted from the satellite 122 or the network 131was received in the communications department 148and was installed on the hard disk 102Or the program which was read from the floppy disk 111 with which the drive 149 was equippedCD-ROM112MO disk 113DVD114or the magnetic disk 115and was installed on the hard disk 102It loads to RAM(Random Access Memory) 144and performs. And CPU142 outputs the processing result to the indicator 146 which comprises LCD (Liquid CryStal Display) etc. via the input/output interface 145 if neededfor example.
[0146]By linearity primary prediction class sorting application processing performs study which calculates a prediction coefficient for every class using teacher data and student dataand using the prediction coefficient and input data. Since the predicted value of teacher data is calculatedit becomes possible from input data to obtain the prediction coefficient for calculating a desired predicted value with the teacher data and student data which are used for study. That iswhile using a picture without dotage as teacher data for examplethe prediction coefficient which improves dotage can be obtained by using the picture which added dotage to the picture as student data. While using the picture which does not contain a noise as teacher data for examplethe prediction coefficient which removes a noise can be obtained by using the picture which added the noise to the picture as student data. Thereforethis invention can be appliedwhen improving dotagewhen [other] performing waveform equalizationfor exampleand when [when removing a noise besides in the case of raising resolution which was mentioned above or].

[0147]In this embodimentalthough video was set as the object of class sorting application processingit is possible to be further aimed at a still picturea soundthe signal (RF (RadioFrequency) signal) reproduced from the recording medium besides videoetc.
[0148]In this embodimentalthough a class tap and a prediction tap will be constituted from being constituted according to the same tap information by the same pixelIt is possible to have different composition from a class tap and a prediction tapi.e.also constitute according to different tap information.
[0149]Although both a class tap and a prediction tap are seen from a noticed picture element and SD pixel of the variable position constituted it from this embodiment according to tap informationIt sees from a noticed picture element and either a class tap or the prediction taps can be constituted from an SD pixel of a fixed position.
[0150]Although SD pixel [be / SD pixel which constitutes the tap / an extremum] which makes a tap constitute based on the error over the dynamic rangeapproximation straight linesetc. was determined in this embodimentIt is possible to determine SD pixel which makes a tap constitute based on the feature (waveform characteristic) on the waveform of SD pixel which constitutes taps other than these.
[0151]Although SD pixel which makes a tap constitute was determined in this embodiment for for [every] all directions which make a central pixel the starting pointit is not necessary to necessarily determine the pixel which makes a tap constitute for such every direction.
[0152]Although the image processing device and the learning device which learns the prediction coefficient for every class used with the image processing device were constituted from this embodiment as a separate deviceit is also possible to constitute these image processing devices and learning devices in one. And it is able to make it to make the prediction coefficient which makes learn to a learning device in real timeand is used for it with an image processing device update in real time in this case.
[0153]At this embodimentalthough it was made to make coefficient RAM5 memorize the prediction coefficient for every class beforehandthis prediction coefficient can also be made to supply an image processing device with an inputted image (SD picture) for example.
[0154]A class tap and a prediction tap can also be constituted using the pixel which exists in the direction of spaceand which direction of a time direction.
[0155]In learning processingas mentioned abovethe add lump equivalent to the summation (sigma) of a formula (7) is performed using a prediction tapbut. The add lump using the prediction tap which comprises an SD pixel of a position which sees and is different from a noticed picture element is performed for the pixels to which those prediction taps correspond.
[0156]namelydirection D_1 of 16 shown in drawing 3 by this embodiment supposing it constituted the basic tap from 5x5 pixels 25 pixels centering on a central pixelas shown in drawing 3 thru/or D_{16} -- a prediction tap comprises arbitrary pixels on

each. Thereforealthough it comprises a pixel in a position which regards as a certain prediction tap and other prediction taps from a central pixeland is differentIn this casefor examplein a certain prediction tapthe pixel as a tap which is in the 1st from the central pixel of direction D_1 is added in other prediction taps with the pixel as a tap which is in the 1st from the central pixel of direction D_1.
[0157]Class sorting is also performed from same viewpoint. Namelyeach pixel (pixel value) as a tap for all directions which constitute a certain class tapfor exampleWhen equal to each pixel as a tap in the turn of corresponding from the central pixel of a corresponding direction which constitutes other class tapsthe class sorting result of having used each of the two class taps becomes the same (class sorting is carried out to the same class).
[0158]
[Effect of the Invention]According to the 1st data processing device of this inventiona data processing methodand the mediumlike the above. Based on the waveform characteristic of input datatwo or more data extracted from input data is determinedand two or more data is extracted from input data about the attention output data which is output data which is going to calculate a predicted value according to the determination. And the predicted value of attention output data is calculated based on two or more of the extracted data. Thereforeit becomes possible to calculate the predicted value near attention output data.
[0159]According to the 2nd data processing device of this inventiona data processing methodand the mediumthe student data which serves as a student is generated from the teacher data which serves as a teacher for study of a prediction coefficientand two or more data extracted from student data is determined based on the waveform characteristic of the student data. And about the attention teacher data which is teacher data which is going to calculate a predicted value according to the determinationtwo or more data is extracted from student dataand a prediction coefficient is calculated based on two or more of the extracted data. Thereforeit becomes possible to obtain the prediction coefficient which can calculate the predicted value near teacher data.
[0160]According to the 3rd data processing device of this inventionbased on the waveform characteristic of input datatwo or more data extracted from input data is determinedand two or more 1st data is extracted from input data about the attention output data which is output data which is going to calculate a predicted value according to the determination. And the predicted value of attention output data is calculated based on two or more of the 1st extracted data. On the other handthe student data which serves as a student is generated from the teacher data which serves as a teacher for study of a prediction coefficientand two or more data extracted from student data is determined based on the waveform characteristic of the student data. And about the attention teacher data which is teacher data which is going to calculate a predicted value according to the determinationtwo or more 2nd data is extracted from student dataand a prediction coefficient is calculated based on two or more of the extracted data. Thereforeit becomes possible to calculate the predicted value near attention output data by

using the prediction coefficient.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is a block diagram showing the example of composition of the 1 embodiment of the image processing device which applied this invention.
[Drawing 2]It is a figure showing a basic tap.
[Drawing 3]It is a figure for explaining processing of the tap determining circuit 7 of drawing 1.
[Drawing 4]It is a figure for explaining processing of the tap determining circuit 7 of drawing 1.
[Drawing 5]It is a flow chart for explaining the resolution improvement processing by the image processing device of drawing 1.
[Drawing 6]It is a flow chart for explaining the 1st tap decision processing in Step S1 of drawing 5.
[Drawing 7]It is a figure for explaining the 1st tap decision processing in Step S1 of drawing 5.
[Drawing 8]It is a flow chart for explaining the 2nd tap decision processing in Step S1 of drawing 5.
[Drawing 9]It is a figure for explaining the 2nd tap decision processing in Step S1 of drawing 5.
[Drawing 10]It is a flow chart for explaining the 3rd tap decision processing in Step S1 of drawing 5.
[Drawing 11]It is a figure for explaining the 3rd tap decision processing in Step S1 of drawing 5.
[Drawing 12]It is a block diagram showing the example of composition of the 1 embodiment of the learning device which applied this invention.
[Drawing 13]It is a flow chart for explaining the learning processing by the learning device of drawing 12.
[Drawing 14]It is a figure for explaining the medium which applied this invention.
[Drawing 15]It is a block diagram showing the example of composition of the computer 101 of drawing 14.
[Description of Notations]
1 A frame memory and 2 A class tap generating circuit3 A prediction tap generating circuit and 4 class sorting circuits5 coefficient RAM6 prediction arithmetic circuitsand 7 tap determining circuit61 A frame memory and 62 infanticide circuits63 A frame memory and 64 A class tap generating circuit65 A prediction tap generating circuit and 66 class sorting circuits67 An adder circuit and 68 prediction-tap memory69 adder circuits and 70 Teacher data memory71 An arithmetic circuit and 72 A tap determining circuit101 computers and 102 A hard disk103 Semiconductor memory and 111 A floppy disk112 CD-ROM and 113 MO disks114 DVD115 magnetic disksand 116. Semiconductor memory and 121 A

download site122 A satellite and 131 [An input part and 148 / The communications department and 149 / Drive] A network and 141 A bus142 CPU143 ROM144 RAM145 input/output interfacesand 146 An indicator and 147
